Search for $ZH \rightarrow \ell^+\ell^- b\bar{b}$ at DØ

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On Behalf of the DØ Collaboration

Lake Louise Winter Institute
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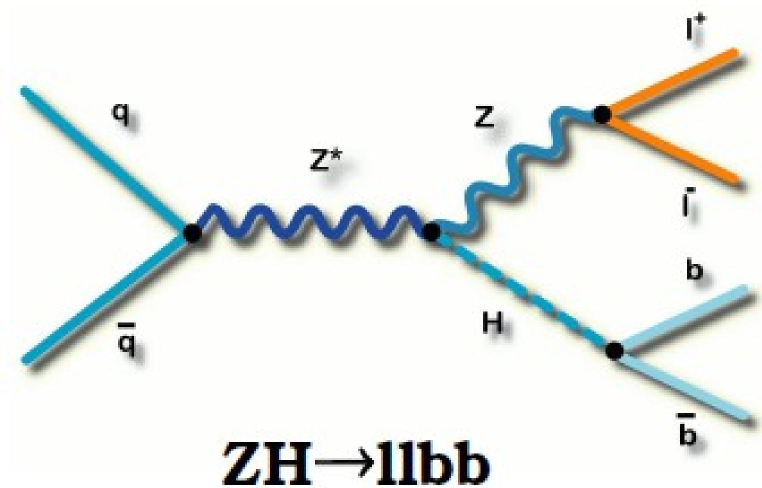
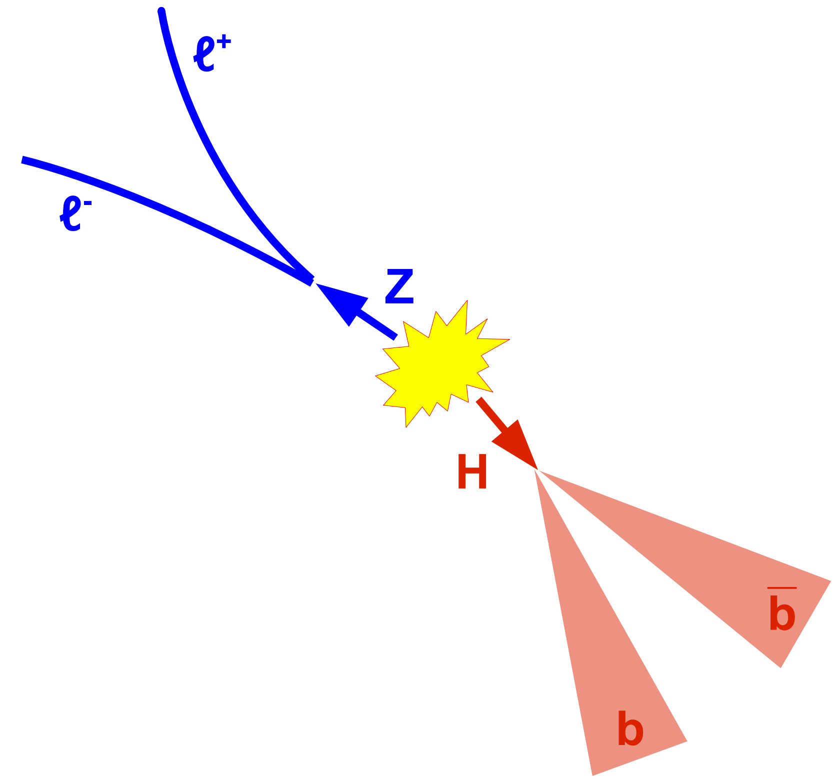
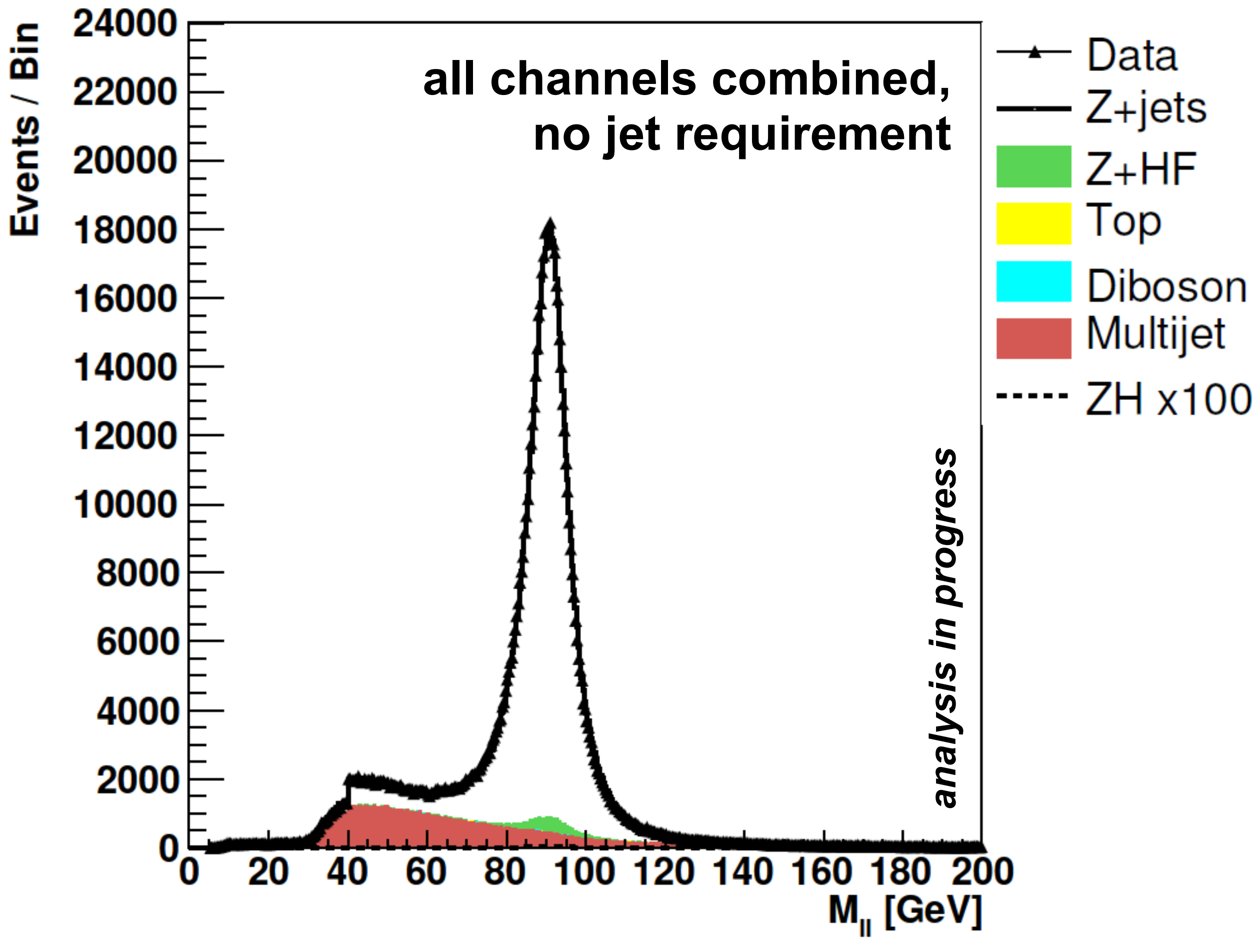


- $114 < m_H < 186$ GeV with low masses preferred
- SM Higgs below 135 GeV decays mostly to $b\bar{b}$
- $\sigma(p\bar{p}\to b\bar{b}) \approx 10^6 \cdot \sigma(p\bar{p}\to H\to b\bar{b})$
- Reduce multijet background: look for associated $Z\to\ell^+\ell^-$ – **S/B 300x better**



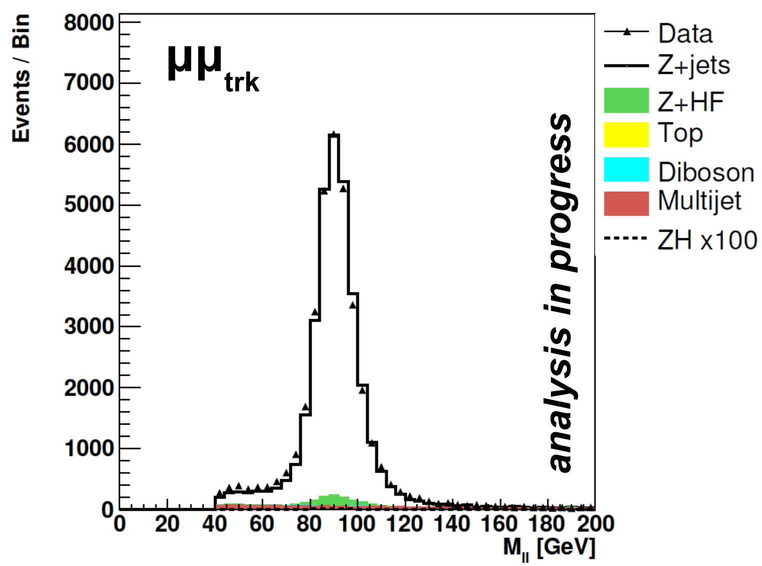
- Final state: 2+ charged leptons (e, μ), 2+ b-jets
- Irreducible background: $Z+b\bar{b}$, VZ, top pairs
- Instrumental background: b-tagged light jets, leptons identified as jets
- Strategy: **accept as much signal as possible & use all available information**

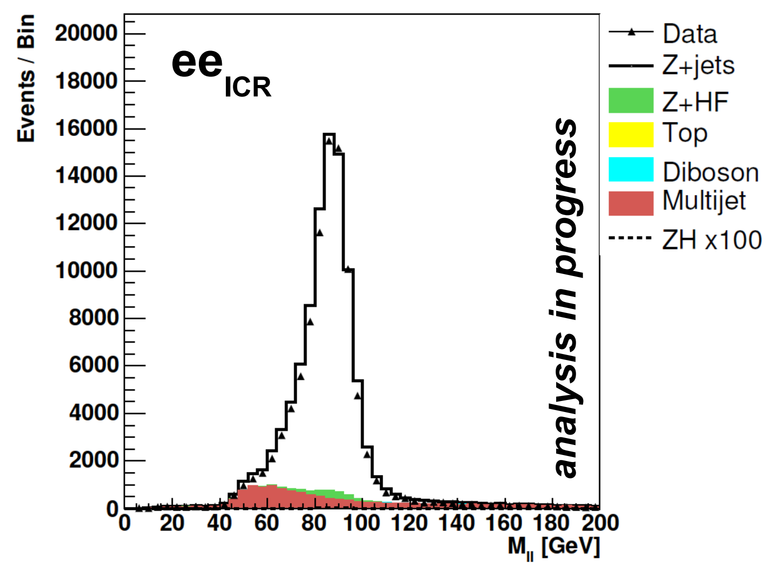
Z Selection



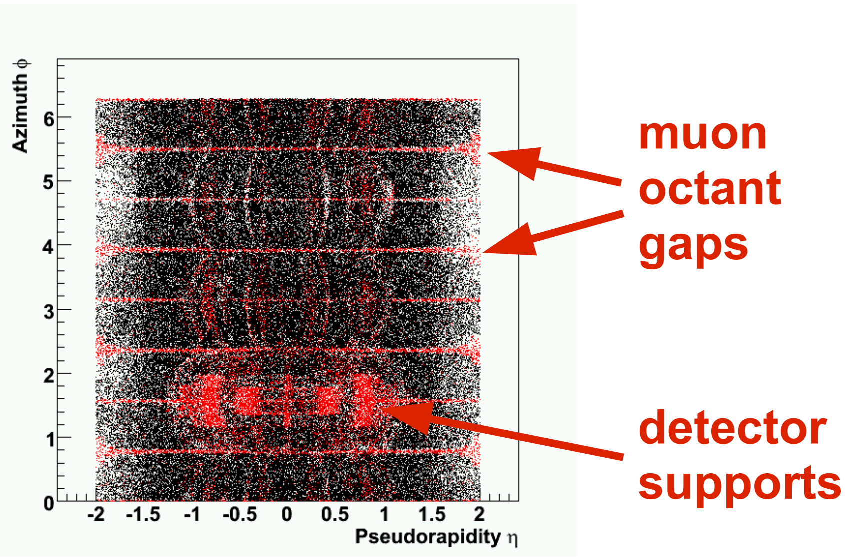
- Decay to muons: one muon $p_T > 15$ GeV, $|\eta| < 1.6$; other muon $p_T > 10$ GeV, $|\eta| < 2$
- Decay to electrons: $p_T > 15$ GeV, $|\eta| < 1.1$, $1.5 < |\eta| < 2.5$
- $60 < m_{\ell\ell} < 150$ GeV, isolated in calorimeter & tracker

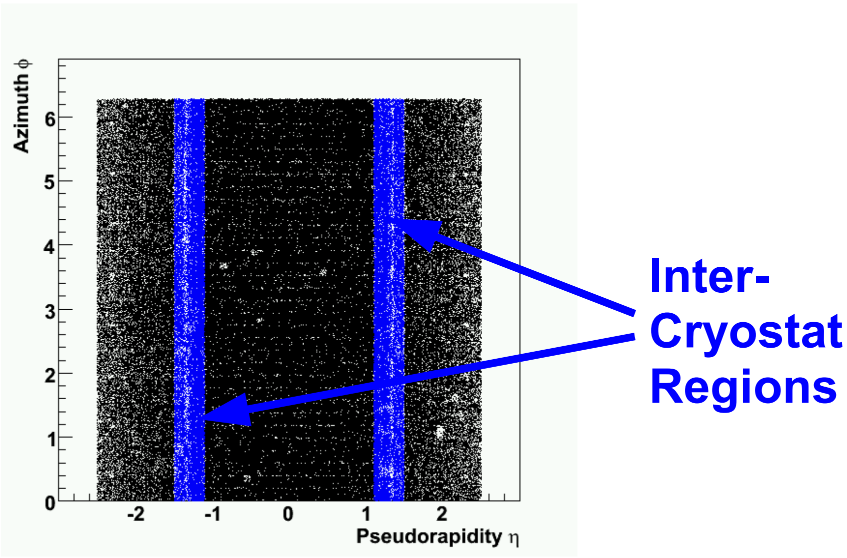
Z Selection





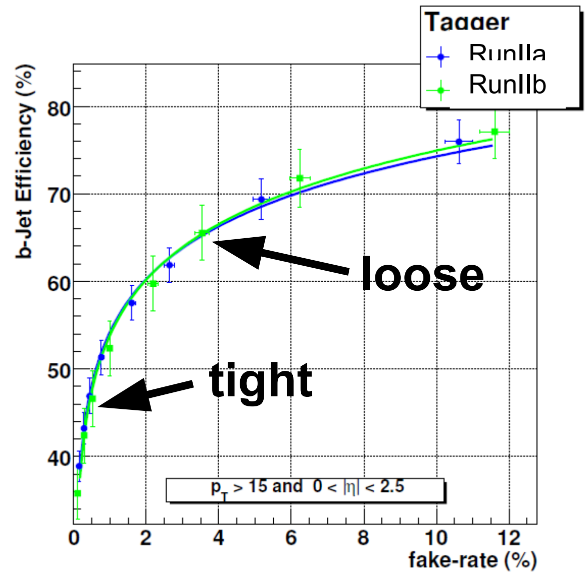
- Fill in gaps in coverage: identify muons as **isolated tracks**, electrons in **ICR** (between central and forward calorimeters) → **15% improved signal acceptance**

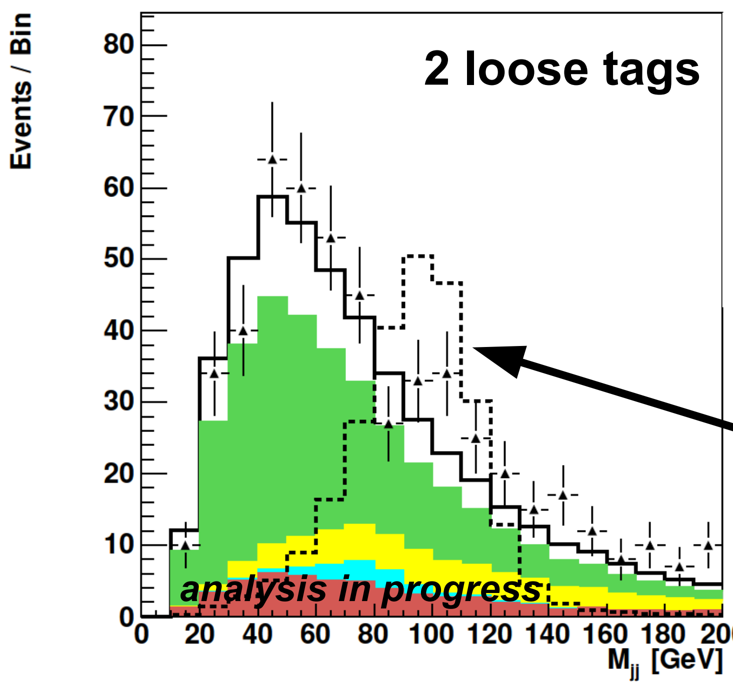




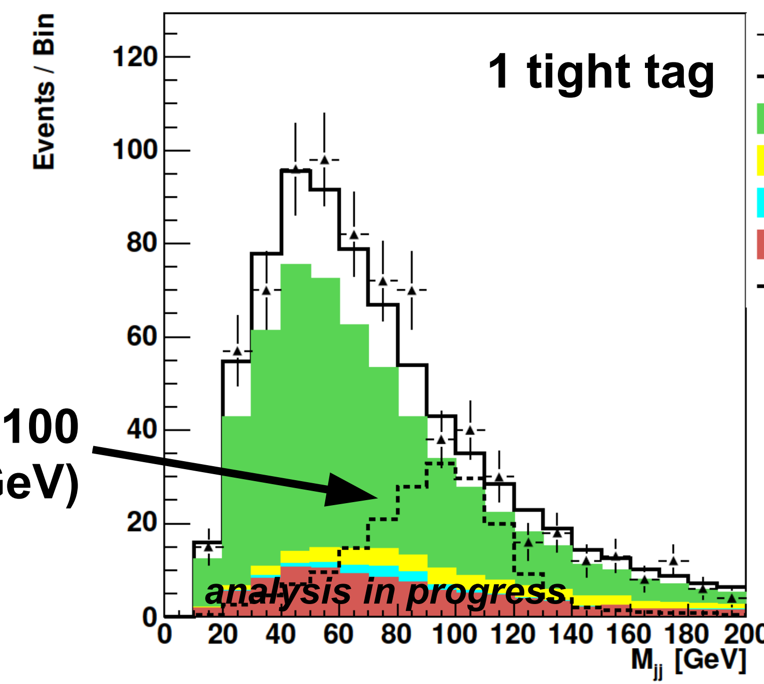
$b\bar{b}$ Selection

- Leading jet p_T > 20 GeV, other jets p_T > 15 GeV – S/B = 0.0003
- Use neural network *b*-tagger to identify *b*-jets:
  - At least 2 loose *b*-tagged jets – **S/B = 0.006**
  - Exactly 1 tight *b*-tagged jet – **S/B = 0.003**



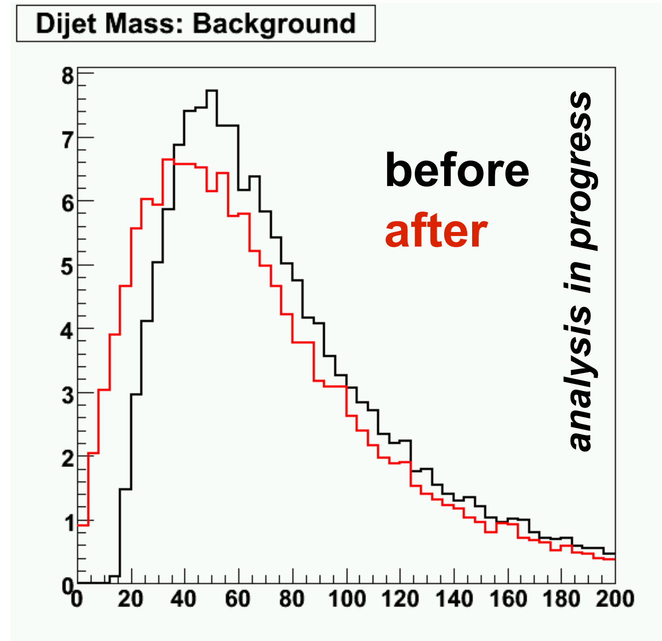


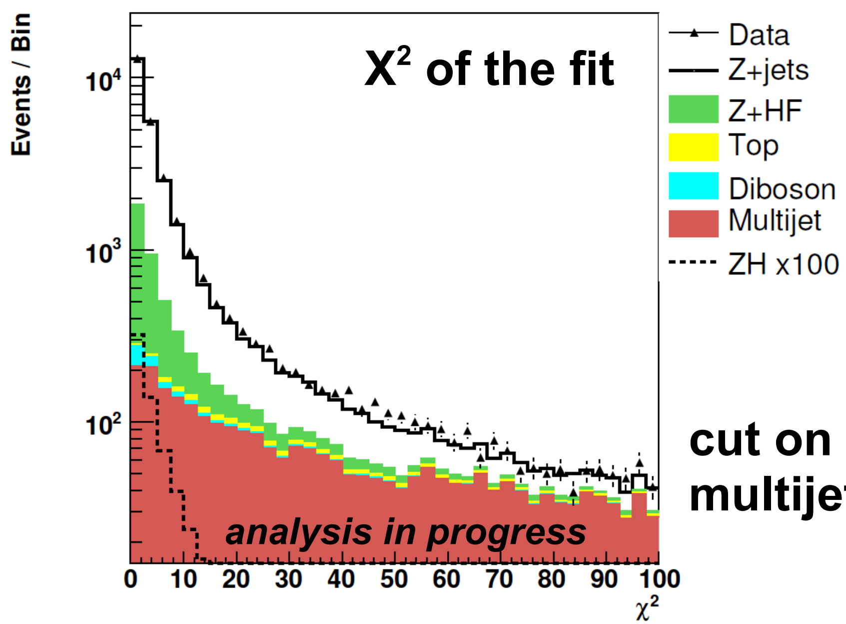
ZH signal x100
(m_H = 115 GeV)



Kinematic Fit

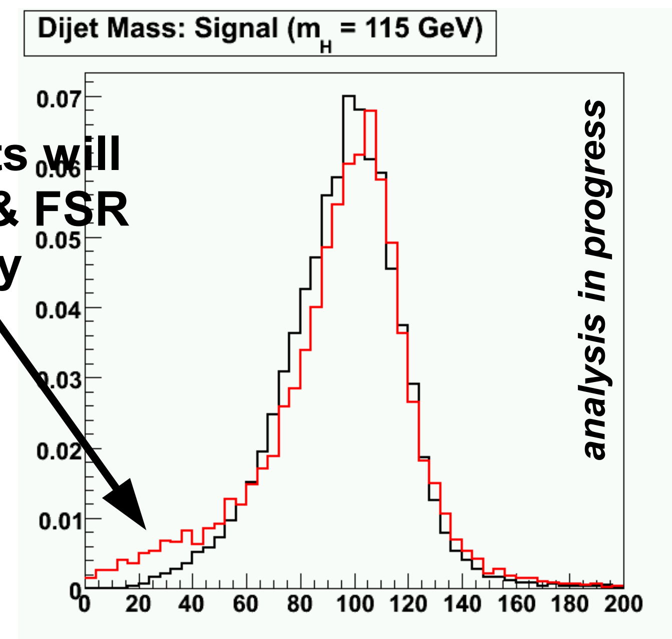
- $ZH \rightarrow \ell\ell bb$ final state is well-constrained: small missing energy, well-measured Z resonance
- To improve the dijet mass resolution and discriminate against non-Z background, allow the jet and lepton p_T, η, φ to vary within their resolutions, with constraints:
  - Dilepton mass = 91.2 ± 2.5 GeV
  - Vector sum of p_T's = 0.0 ± 7.0 GeV
- **Significance under Higgs peak improves 5-10%**

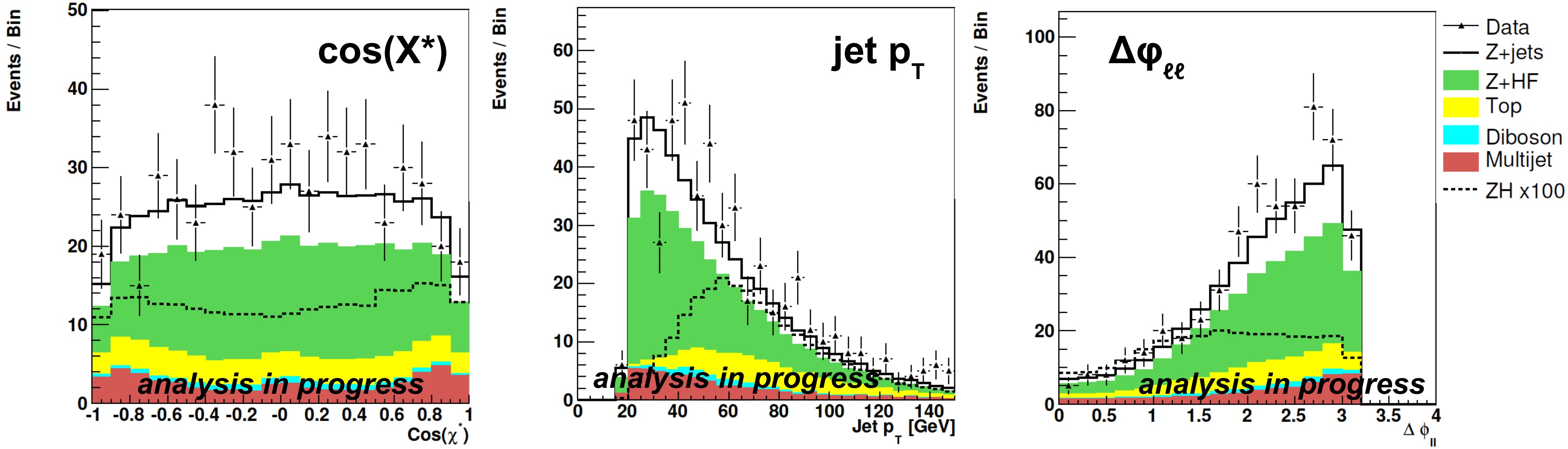


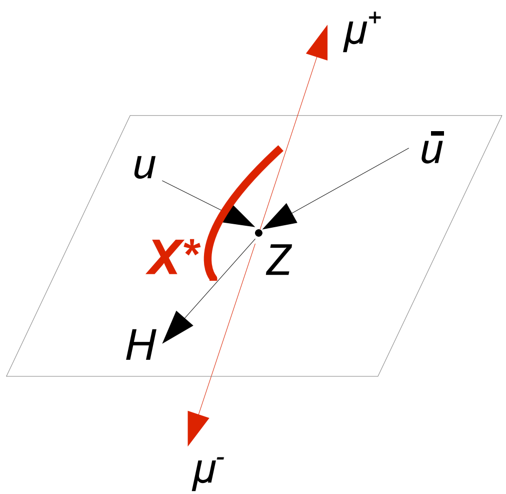


cut on X^2 to reduce multijet, top background

future efforts will handle ISR & FSR properly



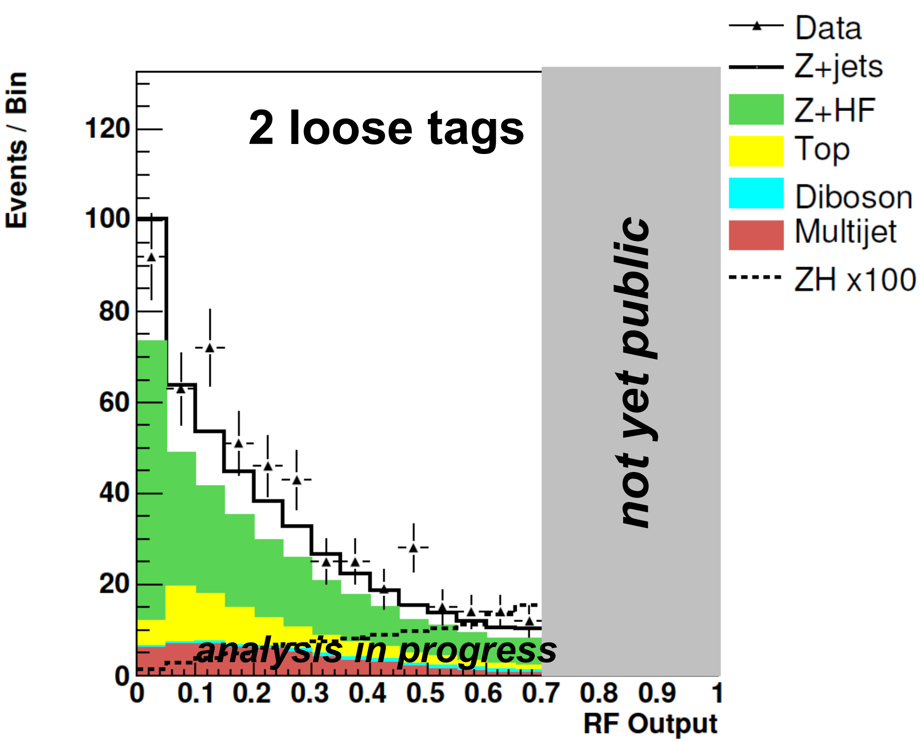


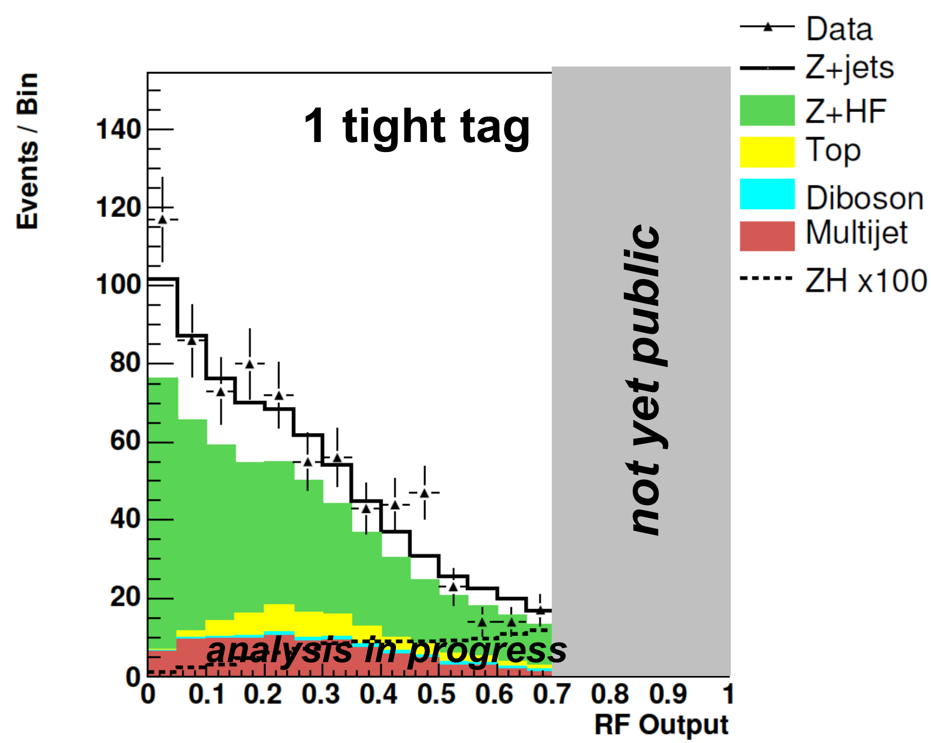


- Dijet mass is most powerful single variable, but many **other variables show significant separation power**
- Angle between $b\bar{b}$ system and lepton in Z rest frame exploits angular behavior:
  - scalar Higgs vs. vector gluon
  - s-channel ZH vs. t-channel Z+jets

Random Forest

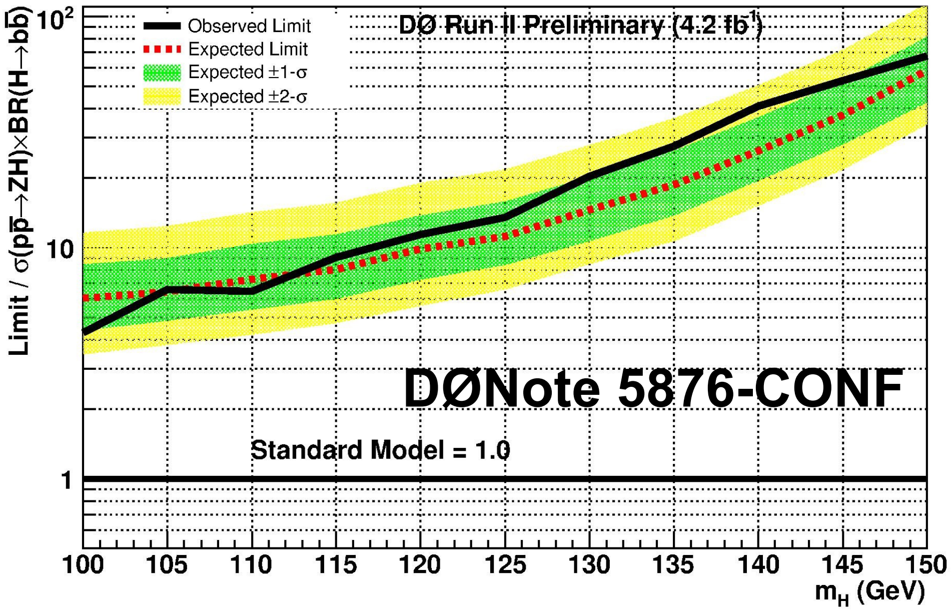
- Decision trees handle correlated input variables better that neural nets, but individual trees can be unstable
- Random Forest: train several trees, each one using a random subset of the training sample, and a random subset of variables at each node—**average over forest outperforms individual tree**
- For each hypothetical Higgs mass (100 – 150 in 5 GeV steps) and *b*-tagging sample, we trained a random forest of 200 trees

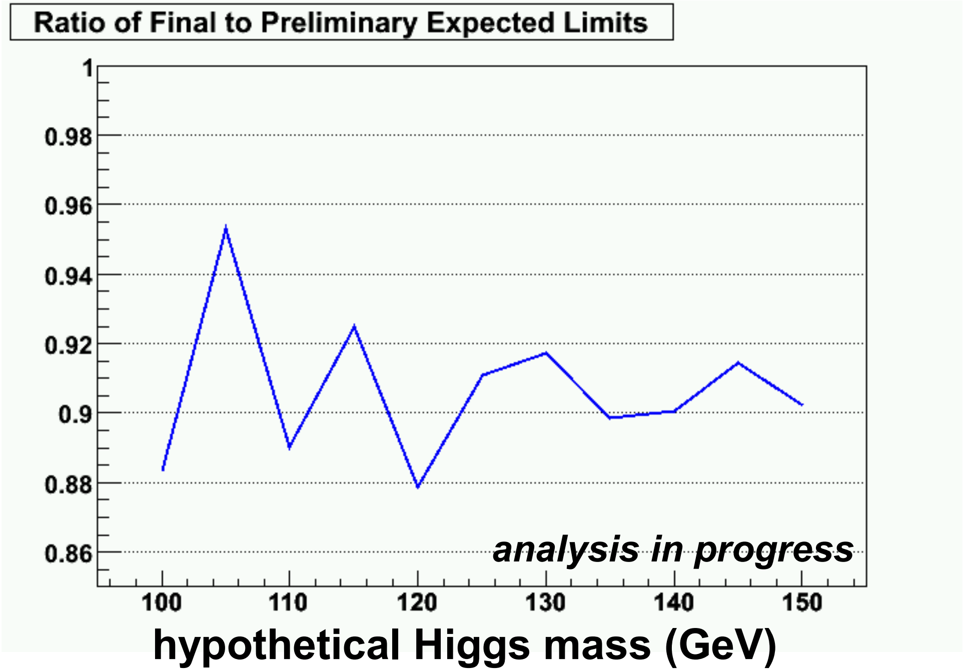




Results

- 4.2 fb^{-1} of data analyzed
- Preliminary Moriond '09 *ZH* limit: 9.1 (8.0) x SM observed (expected) at m_H=115 GeV
- Much work was done to refine the analysis and produce final results with the same data
- **Expected final limit 6-11% better than preliminary**



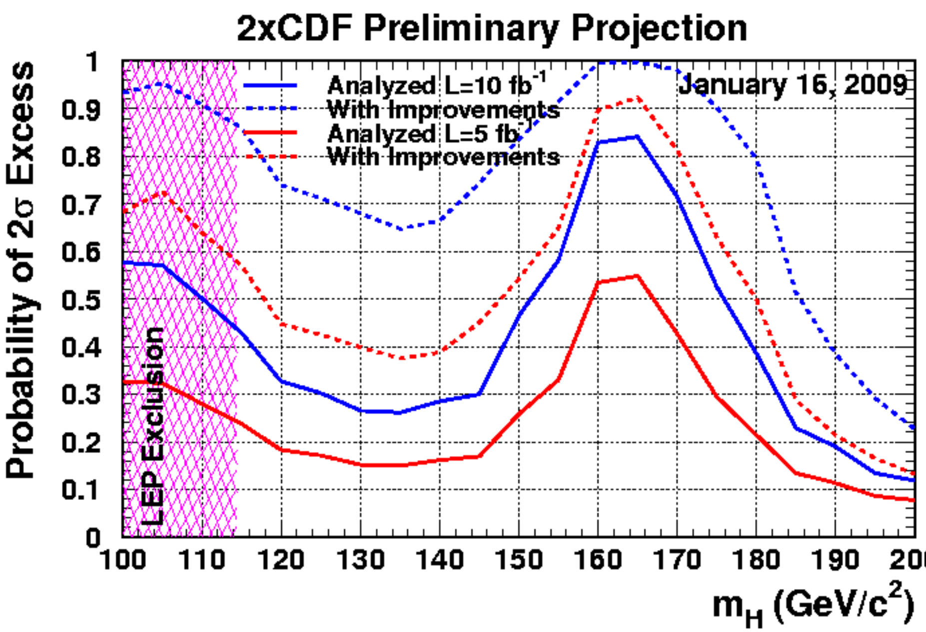


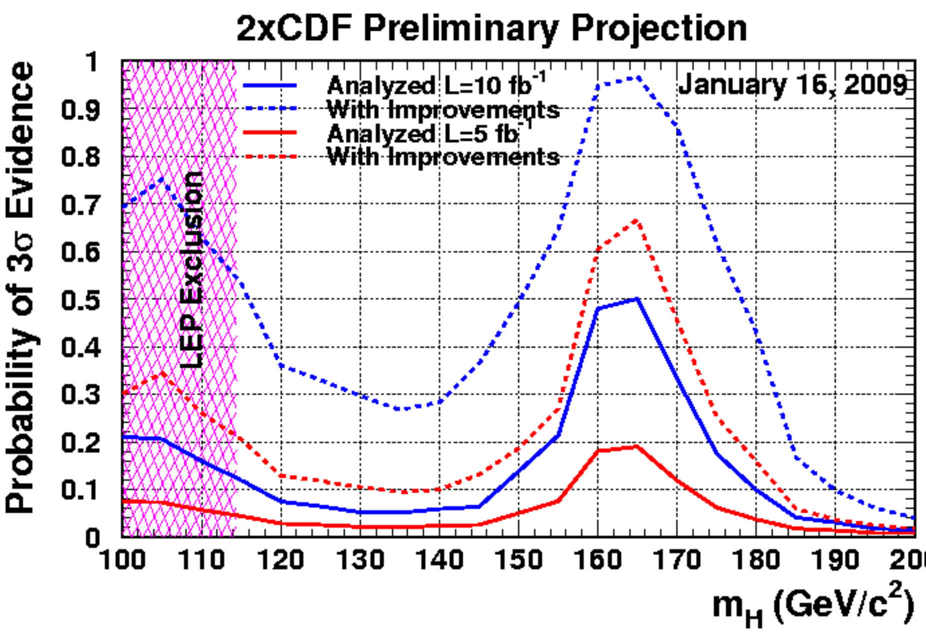
Outlook

- Final result on 4.2 fb^{-1} is coming soon!
- Data continues to accumulate:
  - DØ steadily taking data at or above 90% efficiency
  - Tevatron is performing very well: ~60 pb^{-1} per week
  - Almost 7 fb^{-1} already recorded by DØ, and run through 2011 is very likely
- Many ways to improve the analysis:
  - Loosen *b*-tagging and lepton ID criteria
  - Analyze 2, 3-jet events separately
  - Handle initial and final-state radiation properly
  - Use more calorimeter and tracking information to improve dijet mass resolution
  - Et cetera...
- With a well-constrained final state and small instrumental background, ***ZH→ℓℓbb*** **is essential in the search for low-mass Higgs bosons at the Tevatron**

BACKUP

Projections from CDF





- Probability of 2σ excess with 10 fb^{-1}: 40% with analyses as-is, 85% with factor of 1.5 improvement in sensitivity
- Probability of 3σ excess with 10 fb^{-1}: 10% with analyses as-is, 50% with factor of 1.5 improvement in sensitivity
- With run in 2011, total integrated luminosity will exceed 10 fb^{-1}